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THE GIRASOLE OR JERUSALEM ARTICHOKE, A NEGLECTED SOURCE OF FOOD

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THE sunflowers, genus *Helianthus,* are native only in the Western Hemisphere. Botanists recognize about 70 valid species in America north of Mexico; but Mr. S. Alexander, who minutely studied the sunflowers of Michigan, recognized some hundreds of forms, which he regarded as species. These have not yet been described. About a dozen species are known from Mexico, one is recorded from Guatemala, and about 25 come from South America, nearly all from the mountains of Chile and Peru. The South American sunflowers need investigation, but the materials for a revision do not exist in American herbaria. Only two or three of those represented in the herbarium of the New York Botanical Garden appear to be genuine *Helianthus,* but one collected by R. Pearce at an altitude of 8,000 feet in Bolivia, and also collected in Bolivia by Rusby, is quite of the type of the North American perennial species.

It is in the northeastern United States and adjacent Canada that species of *Helianthus* develop edible tubers. Mr. S. Alexander, who paid particular attention to the root-system, distinguished a great group of sunflowers which possess no permanent crown, but reproduce annually by seeds and earth-branches. These he called "binatal annuals," although they are ordinarily classed as perennials. They are of course perennial in the same sense as the potato. A key based on Mr. Alexander's manuscript subdivides this group as follows:

- Leaves petioled.
  - Petioles winged.
    - Species with cord-like migrators................*Helianthus* sp.
    - Division *Tuberosæ* (Alexander), with distal ends of migrators bearing tubers......................*H. tuberosus* and allies.
  - Petioles not winged..............................*Helianthus* sp.
- Leaves not petioled.
  - *H. doronicoides, H. mollis, H. ciliaris, H. radula, H. cinereus.*

The last is a very miscellaneous lot, the species not closely related. *Helianthus tuberosus* is the Jerusalem artichoke. The Tuberosæ, according to Mr. Alexander, include *H. tuberosus* and its variety *subcanescens* of Gray, and "at least 100 or more well-marked species," all of which are undescribed. These latter would probably not be considered species by most botanists, but their comparatively slight differences may prove very important in the development of horticultural types.

In both the potato and the Jerusalem artichoke the tubers arise from underground stems, the earth-branches of Alexander. As has been pointed out by Reed (1910), the tubers of the potato are terminal, whereas those of the *Helianthus* are formed laterally as well, or the earth-branch itself may swell up and become a tuber. Consequently the *Helianthus* bears a mass of tubers close to the crown, though others may be more widely separated in the soil. It results from this arrangement that the tubers are very easy to harvest, and the tuber-bearing region occupies a surprisingly small space, considering the quantity of the tubers.

Helianthus tuberosus is not the only member of the genus which has been used as a source of edible tubers. *H. subtuberosus*, the so-called Indian potato of Michigan and Minnesota to Saskatchewan and Montana, has thick fleshy edible tubers. It was used by the Assiniboines. *H. doronicoides,* native from Ohio to Missouri and Arkansas, is used as food in Europe. Vilmorin of Paris offers it for sale, remarking that "les rhizomes de cette plante, produits en abondance, peuvent être consommeés à la facon de salsifs." It has been found by von Héries-Tóth and von Osztrovsky (1911) that the tubers of *H. doronicoides* are good raw material for the production of alcohol, while the refuse contains considerable amounts of fat and protein, and can be fed to stock.

Helianthus tuberosus, as a source of food, was well known to the natives of America long before the advent of the white man. Dr. V. Havard (1895), in an account of the food-plants of the North American Indians, says:

> The first place belongs to the Jerusalem artichoke (*Helianthus tuberosus* L.). It produces many edible tubers, sometimes two inches in diameter, in our day mostly used for the feeding of cattle, horses and pigs, but which were precious to the Indians on account of their hardiness and prolificacy, retaining possession of the soil for many years. These tubers were mentioned by Champlain in 1603, and brought to France by Lescarbot, who, in 1612, describes them as being "as big as small turnips, excellent to eat, with the taste of artichoke but more agreeable, and multiplying in a wonderful way." As the plant is native of the valleys of the Ohio and Mississippi, and does not reach any part of Canada, it is evident that the Canadian and New England Indians who planted it must have obtained it from the tribes further south and west, so that we may infer a rather large area of cultivation. The Jerusalem artichoke is, so far, the only contribution of North America, exclusive of Mexico, to the vege-

table garden of the world, and it can be said to be an aboriginal contribution. Strange to note, it is now much more cultivated in the Old World than on this continent.[1]

The tubers appear to have been highly appreciated in Europe from the first. The plant was grown in the Farnese Garden at Rome, and was distributed thence under the name Girasóle Articiocco, or sunflower artichoke. It was early reputed, by some mistake, to be a native of Brazil, and this error crops up in various compilations, down to recent times. Venner (1620) stated that the tubers were usually eaten with butter, vinegar and pepper. Parkinson (1629) noted that they were very commonly offered for sale in London.

The name artichoke is supposed to be derived from the Spanish-Arabic alkharshof, applied to the thistle-like plant *Cynara scolymus,* a native of the Old World. This is the true artichoke, and the edible part is the flower-head, particularly the thickened involucral bracts. Thus the true artichoke and the Jerusalem artichoke have little in common, the plants being entirely different in appearance, and furnishing quite different parts as food. The name artichoke appears to have been given to the *Helianthus* solely on account of the more or less similar flavor, while "Jerusalem" is an English corruption of the Italian "Girasole," or sunflower. Thus the designation "Jerusalem artichoke" is as misleading as "guinea pig," or "Christian Science."

The confusion resulting from the name necessitates considerable caution in using published records. Thus in Edw. Smith's well-known book on foods (Internat. Science Series), which has gone through ten editions, the two plants are discussed as if they were varieties of one thing, and most of the statements are made as if equally applicable to both. C. E. Quinn (1908), in a Farmers' Bulletin on forage crops for hogs, discusses the *Helianthus* under the name artichoke, with no indication of the fact that it is not the true plant of that name. It is quite common to find the name artichoke thus applied indiscriminately, and unless one knows the difference between the plants, and can find the characteristics mentioned in the text, it is difficult to understand what is intended. The French have a distinctive name, *Topinambour.* This is rather long and difficult to pronounce, but the Italian *Girasole* is short and simple, and is the proper form of the absurd "Jerusalem." We may therefore perhaps use it for our *Helianthus,* though it is open to the objection that to an Italian it means a sunflower, and probably suggests the annual species of gardens rather than any other. Britton and Brown give two English designations, earth apple and Canada potato. The first is objectionable, since pomme-de-terre is French for a potato; while the second is doubly misleading, the plant being neither a potato nor originally specially characteristic of Canada; though to-day it is said to occur from Nova Scotia and Ontario to Manitoba. On the whole, then, Girasole seems the least objectionable term. It is a singular fact, as Havard remarked, that a plant so highly esteemed by the American aborigines, and for three hundred years used in Europe, should find so little favor to-day in the land of its origin. The literature indicates that it is probably even less used now than when Havard wrote, some twenty years ago. Our experience at Boulder having indicated the astonishing size of the crop, and the value of the tubers as human food, we could not understand the apparent neglect. Wishing to ascertain the exact facts, I wrote to a number of experiment stations and to Washington, and am exceedingly indebted to those addressed for their prompt and courteous replies. The following will suffice to show the prevalent opinion:

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[1] *Bull. Torrey Bot. Club,* March, 1895.

U. S. Department of Agriculture. As to the possible usefulness of Jerusalem artichoke as an emergency food, all that you say in regard to its productiveness is thoroughly justified. . . . A new vegetable at best is adopted very slowly . . . it seems to me rather an impressive fact that the plant has not made its way in the United States, although it is undoubtedly a native of this country and has been with us during our whole vegetable gardening history. Apparently there must be some lack of appreciation of its flavor or some difficulty in its production, storing or cooking which has served finally to discourage every enthusiastic advocate who has started to preach its values in the past. I know there must have been many such advocates, and the fact that their labors so far have apparently accomplished so little is to me rather discouraging for a new attempt. (D. N. Shoemaker.) Reference is also made to the difficulty of preparing the irregular tubers for the table. Dr. L. C. Corbett, writing to the U. S. Food Administration (the letter kindly transmitted by Professor V. L. Kellogg), adds another objection—that it would be difficult at present to secure enough seed (*i. e.*, tubers) to plant any considerable acreage. (It would of course be easy by planting this year, to secure plenty for the year following.)

Arizona. We have tried artichokes down at the Yuma Garden; finding, I believe, that they were very badly infested by a lace wing bug of some sort, which spread from them to other plants, including sweet potatoes. We regarded them, therefore, undesirable as a crop. (R. H. Forbes.)

Arkansas. Bulletin 31, a number of years ago, gave details of experiments and analyses. At Newport the yield was 453.75 bushels to the acre; at Fayetteville 612 bushels. The tubers were fed to hogs. There are no recent developments.

Colorado. I do not think that any of our station men are really doing any experimental work with the Jerusalem artichoke. On last Sunday I was in Dean Johnson's garden, where he had planted a few artichokes, and was astonished at the very large yield. One plant had fully a peck of tubers. Artichokes are quite often planted as food for hogs, which do their own harvesting. (C. P. Gillette.) Colorado Exper. Station Bull. 146, on raising hogs in Colorado, and Bull. 199, on Vegetable Growing in Colorado, make no mention of the Jerusalem artichoke.

Connecticut. It is grown occasionally in gardens in Connecticut, but to my knowledge no one has grown it as a crop. (E. H. Jenkins.)

Illinois. This institution has done no work on the raising of Jerusalem artichokes as a crop. (E. Davenport.) We have so many things which seem to be much more important, that we will have to confine our attention to such crops. (W. L. Burlison.)

Massachusetts. Bulletin 47 contains analyses. They were never raised to any extent.

Michigan. This old, well-known plant has been grown very little to my knowledge in this state. We have not tried out any variety of it. . . . Where I have seen it grow, it did not yield sufficiently heavy to give a very large return per acre. (C. W. Waid.)

Missouri. No information available.

Nebraska. We have had no experience with artichokes of any kind or variety. A few have been grown in some sections of the state, but they are grown entirely as hog feed, the hogs being allowed to root them out. (W. W. Burr.)

South Dakota. Jerusalem artichoke was cultivated to some extent years ago for hogs, but I do not know why the matter was not carried on further. I believe the plant could be greatly improved as a crop for feeding to swine. It certainly can be raised cheaply, and the swine can do their own harvesting. (N. E. Hansen.)

Washington State. Our Western Washington Experiment Station has done some work with the artichoke, but we have never considered it a plant of great merit, and have therefore done very little to encourage its production. (Geo. Severance.) Bull. 7, however, gives some remarkable results, cited below.

Wisconsin. We have done nothing with its culture here. It is grown to some extent as a plant upon which to pasture hogs, but I know of no particular work which has been done with it. (J. G. Moore.)

The above statements might be sufficient to discourage any one, but there is another side to the question, and it is worth while to review the principal facts about the plant as a crop, and as a source of food for man and beast.

At Boulder, Colorado, in 1917, we planted the white variety in a field which had been for two years in *Helianthus annuus.* No fertilizer was used, but the soil was exceptionally good for the locality. The tubers were planted three feet apart in the rows, and the rows were two feet apart, each plant thus occupying six square feet. The yield was found to be at the rate of 9.66 tons to the acre. This greatly exceeds the average yield of potatoes. The most astonishing yield is reported from Western Washington by W. H. Lawrence (Bull. 7, Wash. Exper. Sta., 1912). Of the red variety, "335 lbs. of tubers were dug from an area of 360 square feet—at the rate of 20.26 tons per acre." The white variety was even more prolific; "on upland clay near Alequa 2,015 square feet produced an estimated yield of 38.9 tons per acre." (In the Experiment Station Record, XXVIII., p. 531, it is erroneously stated that this yield was in sandy soil.) No wonder the author added:

> Jerusalem artichokes have not been given the attention they should receive. From the experiments it is evident that a large tonnage per acre can be grown of either the white or red variety, and that large yields may be obtained at a low cost.

Yet to-day, in Washington State, the experiment station authorities have lost interest, following the general trend throughout the country. M. Rau (1914) compared the Jerusalem artichoke with the potato on the basis of German experience, and decided that the former was superior as a forage crop, "as it requires less labor to plant and cultivate, yields more heavily in tubers and straw, is of higher food-value, and the tubers have a greater frost resistance" (*Exp. Sta. Record,* XXXI., p. 433). Analyses are given, showing the difference in favor of the girasole.[1] Sutton and Sons of England report that a gardener (J. Barker) planted six pounds of tubers and got 18 stone of "splendid tubers, pure white, with excellent flavor." The Massachusetts Station Annual Report for 1892 records a yield of 8.5 tons to the acre. The Encyclopedia Americana states that the usual yield is 200 to 500 bushels to the acre, but 1,000 bushels are sometimes obtained. The average yield of potatoes per acre in the United States is said to be 84.5 bushels, but Maine, Montana and Nevada average 150–163 bushels.

The girasole can not become a competitor of the potato in such regions as the mountains of Colorado, but it thrives along the foothills and on the plains. S. M. Tracy, in Farmers' Bull. 509 (1912), dealing with forage crops for the cotton region, describes it as a valuable grazing crop for hogs in the northern and central parts of the cotton region, but states that it yields less heavily and is less desirable farther south. He adds that it yields much more heavily than Irish potatoes, and is worth fully as much for feed.

> They are strictly a winter feed, not being well matured until December. From that time on until March they furnish perhaps the least expensive roots grown for hog feed.

Thus, taking the country over, the potato is best adapted to the northern and upland regions, the sweet potato to the south, and the girasole occupies more especially the great intermediate region, as a promising source of tubers. Although the girasole is apparently at a disadvantage southward, it can be grown under an astonishing variety of conditions, considering its rather restricted original habitat. Piper (1911) lists it among the crops grown in the Philippine Islands, and it is grown in South Africa. A special variety is said to be grown in China and Japan. Dr. L. H. Bailey writes me that he saw it freely displayed for sale in China during the past year. C. H. Shinn reported that in California it grew well on alkali soils, where legumes were not successful.

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[1] In Experiment Station Record, XXXI, these figures are accidentally reversed, as I learn from Dr. E. W. Allen.

Under cultivation in Europe, the plant has produced several varieties. Vilmorin (1913) lists the following: (1) *Ordinaire.* (2) *Patate,* with yellow tubers. (3) *Blanc amélioré,* with round white tubers. (4) *Piriforme,* with red tubers, flesh sugary. (5) *Rose,* with oblong tubers, rich in sugar. The last three were introduced by Vilmorin. Sutton, of England (1917), lists *White, Rose* and *Purple,* the last being described as "the old variety," presumably Vilmorin's "ordinaire." The white and rose are described as improved forms introduced by the Sutton firm. Much work in the development of varieties is undoubtedly ahead of us; it may be safely assumed that modern methods of breeding, with more attention to the particular characters desired, will in time greatly improve the plant and give us sorts adapted to special purposes, as in the case of the sugar beet.

Analyses suggest that the food-value is about the same as that of the potato, but, as the carbohydrates are different, further investigation is desirable.[2] Mr. Russell N. Loomis, of the University of Colorado, has kindly analyzed the white variety grown in Boulder, with the following results from two samples, the figures representing percentages:

	Sample 1	Sample 2
Moisture	83.09	83.89
Ash	0.77	0.77
Protein	1.41	1.50
Ether Extract	0.35	0.55
Carbohydrates (direct method)	11.60	10.44
	97.22	96.45
Crude fiber (included in carbohydrates)	0.76	0.69
Carbohydrates (by difference)	14.38	13.29
Calculated on Water-Free Basis		
Ash	4.55	4.57
Proteins	8.31	9.68
Ether Extract	2.06	3.14
Carbohydrates (direct method)	68.53	64.80
Crude fiber	4.48	4.22
Carbohydrates (by difference)	85.03	82.49

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[2] I am greatly indebted to my colleague, Dr. J. B. Ekeley, for advice concerning the chemistry of the plant.

Comparing three German analyses and one in Mass. Bull. 47, we find general agreement. Our water-content is highest, the other records showing about 71.5 to 81 per cent. This may be due, at least in part, to our sample being analyzed soon after digging. There is a marked discrepancy in the ether extract, other analyses giving (as fat) .70 to 1.30 per cent. of dry weight only. My colleague, Dr. Ramaley, remarks that our ether extract doubtless includes the resin, of which there is probably a considerable amount. It is not quite clear, however, that this is excluded from the other analyses, which seem to have been made in the same manner. The protein content is evidently variable, different records showing a range of from 6.20 to 12.82 per cent. of dry weight. The same variability is found in the potato, which showed a range from 6.52 to 17.56 in samples from eight different stations in Germany. The usual analyses give the carbohydrates as "nitrogen-free extract," obtained by deducting the water, ash, protein and ether extract from 100. This is evidently very inexact, as direct analysis gives a much lower figure, as will be seen above. Our figures agree with other analyses, whether made by the one method (Behrend) or the other (Strohmer and Stift, Rau, Mass. Bull. 47).

The whole subject is complicated by the peculiar nature of the carbohydrates in the girasole. The taste is sweet, and there is evidently free sugar. The tubers of Compositæ, as a result of photosynthesis, store up inulin, in place of starch. Inulin has the composition $(C_6H_{10}O_5)_n + H_2O$, and occurs, not in granules, but in solution in the sap. It may be separated out as a white powder, and is slightly soluble in cold and readily soluble in hot water. The saliva does not convert it into sugar, but it is presumably made digestible by being changed into levulose in the stomach by the acid gastric juice. Experiments reported by Sandmeyer (1895), Mendel and Nakaseko and Mendel and Mitchell indicate that inulin may have only moderate value as food; though "inulin" bread and biscuit have been put upon the market, and are supposed to be good for invalids. E. H. S. Bailey[3] states that the girasole tubers "contain 14.7 per cent. of sugar and no starch, but they contain considerable inulin, a substance isomeric with starch." Tanret,[4] who appears to have made the most exact analysis, found two other carbohydrates in the tubers, ***helianthenin***, $12C_6H_{10}O_5 + 3H_2O$, and *synanthrin*, $8C_6H_{10}O_5 + H_2O$. He also stated that the levulin or synanthrose reported by previous authors is a mixture of saccharose (cane sugar) and synanthrin.

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[3] "The Source, Chemistry and Use of Food Products," 1916.

[4] *Compt. rend.*, 1893.

Further investigations may show that the tubers can be used in the manufacture of special products. In Europe they are utilized in the manufacture of alcohol. Edw. Smith notes that 55.9 per cent. of the salts in the tubers is potash, and cultural experiments agree in indicating the value of potash salts as a fertilizer for the crop. Behrend indicates the presence of 3.88 to 6.47 per cent. of dry weight of pentosans, a class of insoluble carbohydrates.

The use of the tubers in feeding stock, particularly hogs, has been referred to above. C. E. Quinn, Farmers' Bulletin 331, states that the girasole "is superior to the common beets and turnips for hogs, and about equal to potatoes, and richer in protein than sweet potatoes." It should not be fed pure, but as part of a mixed ration. S. M. Tracy states that three bushels of tubers fed with one bushel of corn to hogs in the winter are fully equivalent to two bushels of corn, and the fresh feed which the tubers give keeps the animals in much better health than when fed on corn alone. At the Agricultural High School in Berlin the dried leaves and stalks of the girasole were fed to sheep and cows, and found about equal in nutritive value to good meadow hay. It was found advisable to use it as part of a mixed diet. Since the green parts of the plant are very large, there is here another important source of profit. The young plants are sometimes used as food for cattle. Magen reports that peasants in the south of France are in the habit of feeding the tubers to work horses, and get good results. In an experiment they were fed with crushed grain and chopped hay, and no unfavorable results were noted. The ration was found to be very economical, "both on account of the small value of the land on which the artichokes are grown and the ease with which the plant may be cultivated." Various other experiments give essentially similar results, and need not be described.[5]

Girasole tubers can be used as a boiled vegetable, as salad, or in soup. We have found them excellent food, and while the taste often strikes people as peculiar at first, it is easy to acquire a liking for them. Some prefer them to other vegetables. The tubers may be left in the ground during the winter, and dug as required. They are not injured, when thus left out, by the frost. If they are stored, they should be put in pits, with a covering of straw and earth. In preparing them for the table, the irregularity of the tubers is a disadvantage, making them hard to peel. It may be said, however, that the thin skins may be eaten with the rest, and are not objectionable except from the standpoint of appearances. The cook-books consulted give very little information, but Mrs. Cockerell supplies me with the following notes, based on her experience. The tubers have a delicious aroma (due to essential oil) when cooking, and this should be preserved as far as possible by keeping them covered. They should be *put in boiling water,* a few tubers at a time, so as not to lower the temperature; steaming would probably be still better, reducing the loss of soluble contents. The boiling should continue 15–20 minutes (possibly less at sea-level), when the skin is easily removed. At this stage the following recipes may be employed, but in the case of the salad (No. 2) the cooking should last a little longer.

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[5] In looking up references the volumes of the Experiment Station Record (U. S. Dept. Agriculture) are invaluable.

1. Soup may be made with the addition of celery tops rubbed through a colander, with milk or stock or cream added.
2. The cooked tubers sliced with egg or celery or endive, served with French dressing or mayonnaise, make a delicious salad.
3. Slice the boiled or steamed tubers, cover with milk, use salt and pepper to taste, cover with bread crumbs, and then bake for an hour. Grated cheese may be added to this dish.
4. Slice boiled tubers and fry with steak or chops.
5. Slice boiled tubers, mash, add cream, salt and pepper; or cream by adding sliced tubers to rich white sauce, and serve with toast.

It appears that we have in the girasole a plant which produces enormously, and is equally valuable as food for man and beast. In addition to its other merits, we have found it remarkably free from pests; though in Europe there is quite a long list of insects attacking it, many of them primarily infesting the burdock (*Arctium*). It seems impossible to avoid the conclusion that the cultivation of this plant, especially perhaps in small gardens, may add very considerably to the food-resources of the country, at a time when such increase is more than desirable. The greatest obstacles seem to be prejudice and lack of knowledge. In this, perhaps, as in so many other matters connected with the war, our success must depend very largely on our ability to respond to needs and rapidly adjust ourselves to circumstances.